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(54) **CONTROL SYSTEM FOR VEHICLES**

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B64C 13/00   (2006.01)

(52) **U.S. Cl.** **701/7**; 701/2; 701/121; 701/300;
340/989

(58) **Field of Classification Search** .... None
See application file for complete search history.

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(57)   **ABSTRACT**

A system for controlling flight of an aircraft has sensors (**37,
43**), a receiver (**45**), and a digital control system (**57**), all of
which are carried aboard the aircraft. The sensors (**37, 43**)
determine the position of the aircraft relative to the earth and
the inertial movement of the aircraft. The receiver (**45**)
receives transmitted data (**51, 55**) communicating the posi-
tion and movement of a reference vehicle relative to the earth.
The control system (**57**) calculates the position and velocity
of the aircraft relative to the reference vehicle using the data
from the sensors (**37, 43**) and the receiver (**45**) and then
commands flight control devices (**33**) on the aircraft for
maneuvering the aircraft in a manner that maintains a selected
position and/or velocity relative to the reference vehicle. The
system allows use of a graphical or tactile user interfaces.
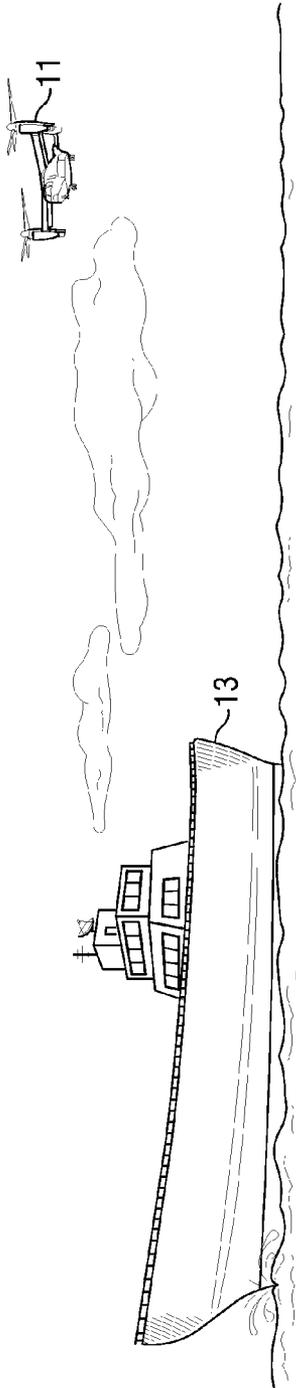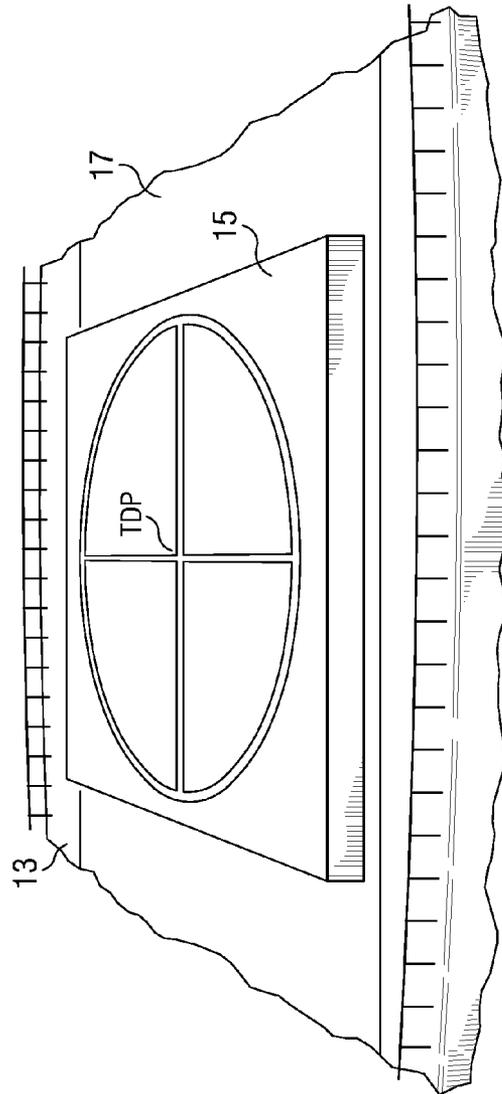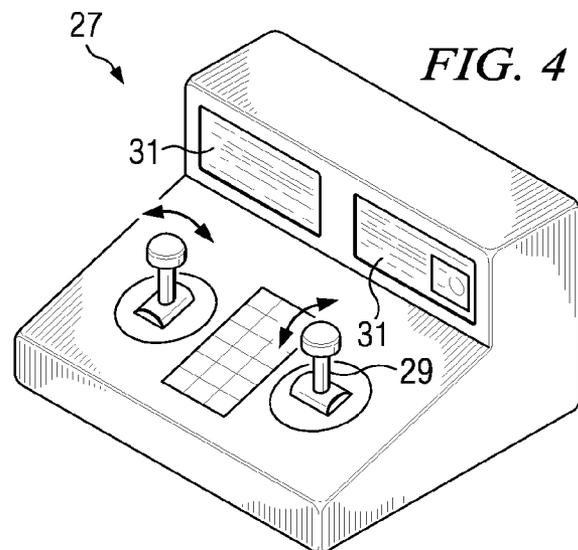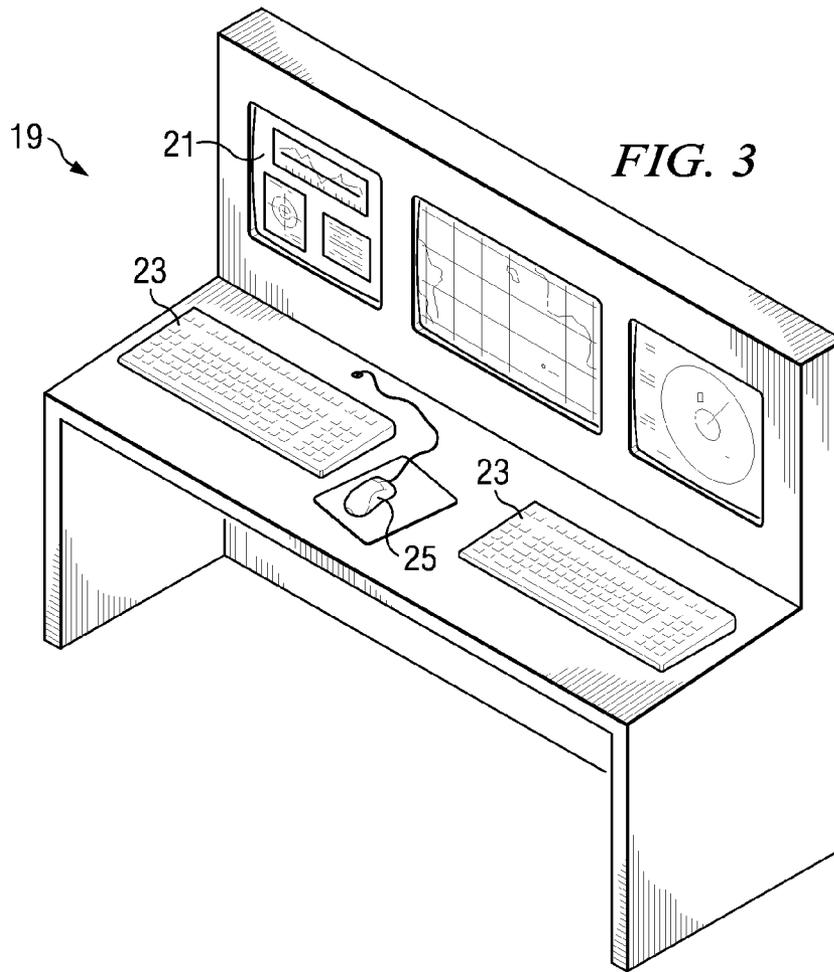
24 Claims, 5 Drawing Sheets

FIG. 1

FIG. 2

19

21

FIG. 3

23

23

25
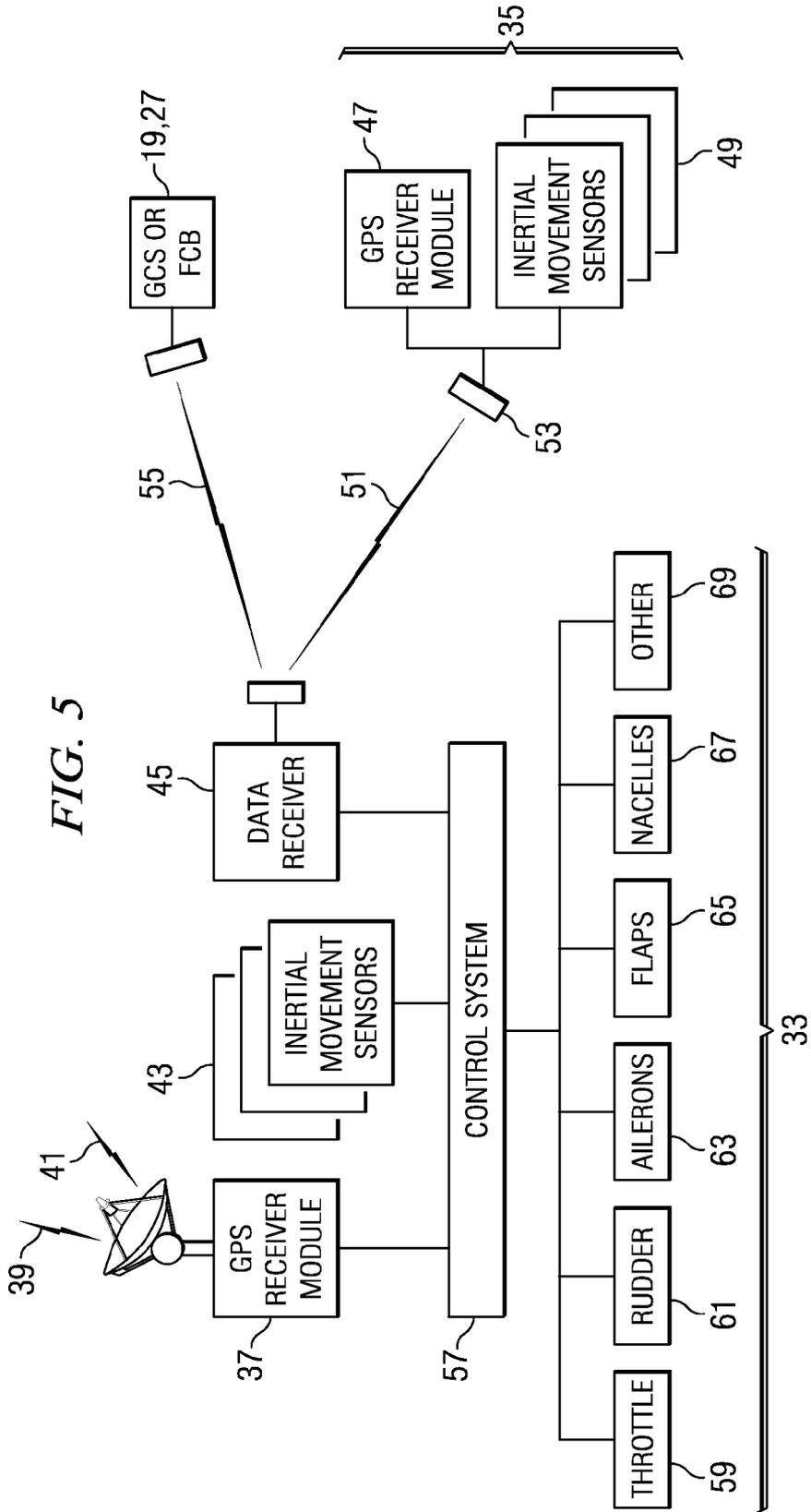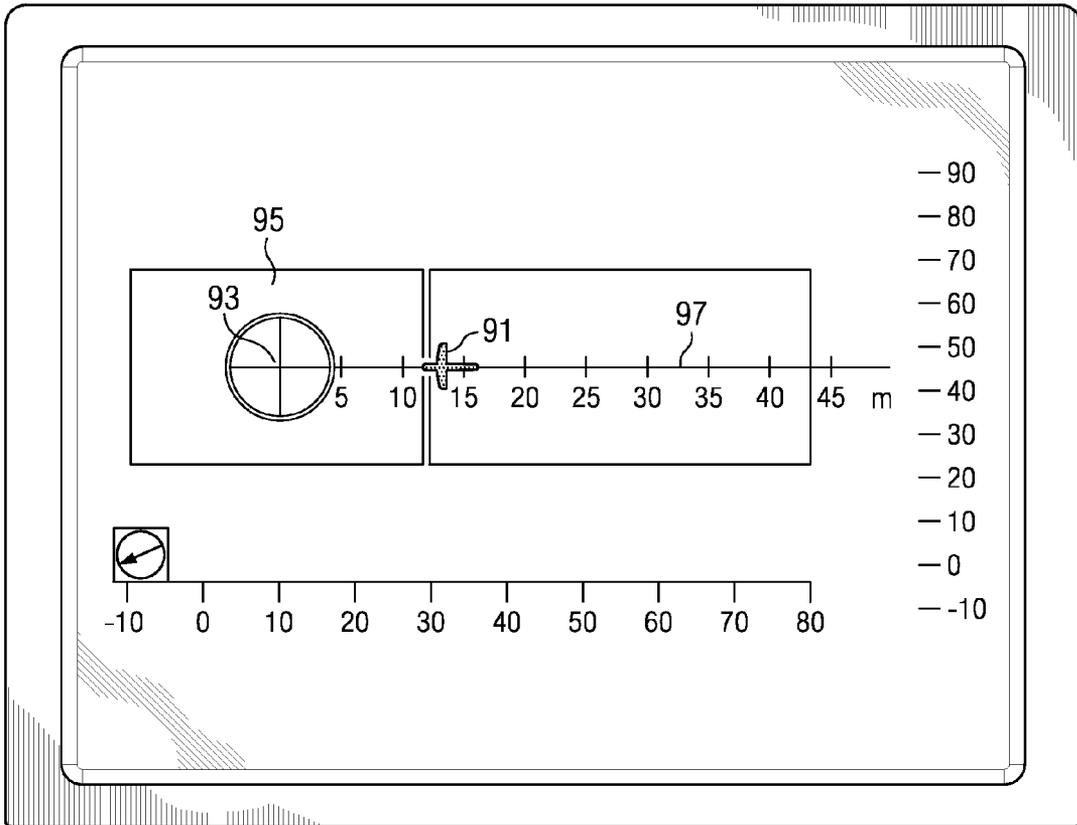
27
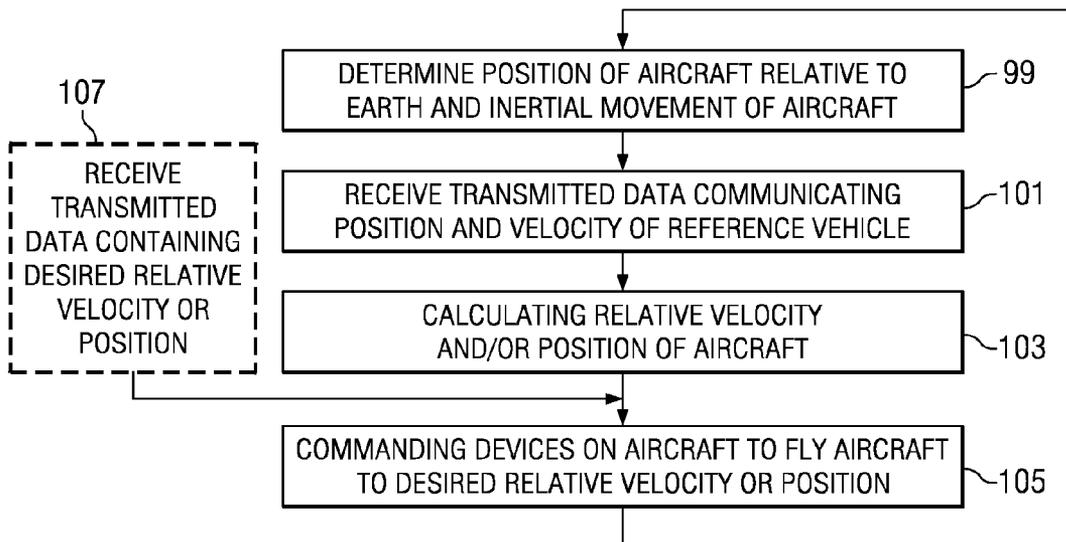
FIG. 4

31

31

29

FIG. 5

FIG. 6
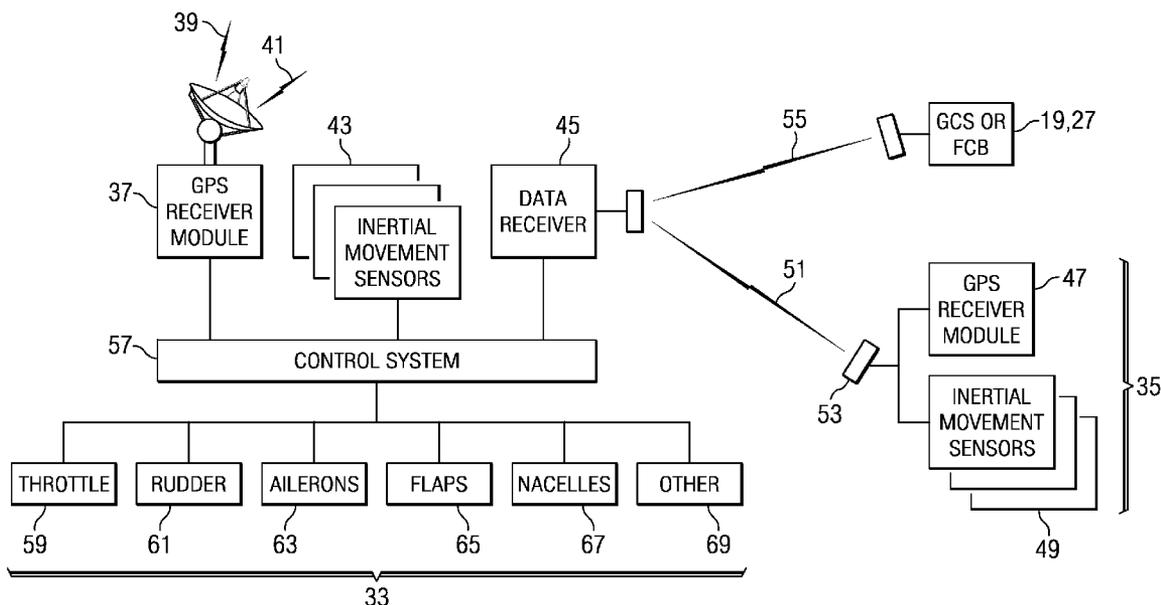
FIG. 7

FIG. 8

CONTROL SYSTEM FOR VEHICLES

TECHNICAL FIELD

The present invention relates in general to the field of control systems for vehicles. In particular, the present invention relates to a control system for causing a vehicle to have a selected position or selected velocity relative to a reference vehicle.

DESCRIPTION OF THE PRIOR ART

Remote control of an aircraft is typically done by commanding the airspeed or inertial speed (groundspeed) of the vehicle, and the direction of the velocity is selected by controlling the heading of the vehicle. The control inputs are usually commands given in terms of the longitudinal, lateral, or directional axis of the aircraft. Therefore, if an operator controlling the aircraft wants the aircraft to move in a certain direction, the operator must know in which direction the aircraft is pointing to determine which axis of control must be used, and in which direction, in order to make the aircraft move in the desired direction. When controlling the aircraft relative to another moving vehicle, the operator must also know the velocity and direction of the moving vehicle.

Several methods of controlling vehicles relative to another vehicle have been used, including using sensors on the controlled vehicle to determine the proximity or position of the reference vehicle. This method has been used in, for example, automotive cruise-control systems, such as those disclosed in U.S. Pub. Nos. US 2002/0072843 and US 2003/0004633. In U.S. Pat. No. 5,768,131, a radar system carried on the controlled vehicle is used to measure the distance and speed relative to vehicles in front of the controlled vehicle. Other systems have included cameras, such as U.S. Pat. No. 6,324, 295 to Valery, et al., or a light source and reflector, such as U.S. Pat. No. 5,530,650 to Biferno, et al., used for determining relative positions and motions of aircraft during refueling.

Although there have been significant developments over the years in the area of remote control of aircraft and other vehicles, considerable shortcomings remain. If an operator wants to operate a controlled vehicle relative to a moving object, such as another vehicle, the operator must consider the position and velocity of both the controlled vehicle and the object, making controlling the controlled vehicle a more difficult task.

SUMMARY OF THE INVENTION

There is a need for an improved control system for vehicles.

Therefore, it is an object of the present invention to provide an improved control system for vehicles.

This object is achieved by providing a system allowing easy control of the position and velocity of a controlled vehicle relative to a reference vehicle or object. A sensor system disposed on the controlled vehicle senses the position of the controlled vehicle and inertial movement of the controlled vehicle, and a receiver disposed on the controlled vehicle receives transmitted data communicating the position and movement of a reference vehicle. The sensor system communicates data representing the position and the inertial movement of the controlled vehicle to a control system disposed on the controlled vehicle for comparison to the data from the receiver, allowing calculation of the position and motion of the controlled vehicle relative to the reference vehicle. Data representing a selected position and/or velocity

of the controlled vehicle relative to the reference vehicle is compared to the calculated relative position and relative velocity, and the control system commands devices on the controlled vehicle to maneuver the controlled vehicle so as to eliminate the error between the calculated and selected values.

For example, the present invention allows control of an aircraft relative to the speed and direction of the reference vehicle. This control is independent of the wind or other motions of the reference vehicle, i.e., motion of a ship at sea that is caused by waves. Also, the velocity and position commands are independent of the attitude or heading of the aircraft or the reference vehicle. In the case of an aircraft approaching a moving ship on which it is to land, the commands can be in the X, Y, Z coordinate system relative to the ship. Thus, a command in the X-direction will move the vehicle in the bow/stem direction and a command in the Y-direction will move the vehicle in the port/starboard direction. A command in the Z-direction will change the vertical position and/or velocity relative to the moving ship.

The aircraft carries sensors for determining the position relative to the earth and inertial movements of the aircraft and carries a receiver for receiving data signals transmitted to the aircraft. The reference vehicle also carries sensors that determine the position and velocity of the reference vehicle relative to the earth. The position and velocity of the reference vehicle are transmitted to the aircraft, and a digital system carried on the aircraft calculates the position and velocity of the aircraft relative to the reference vehicle. These relative values are compared to a selected position and/or velocity, which can be communicated to the digital system by the operator prior to or during flight, and the digital system commands flight control devices on the aircraft to maneuver the aircraft to attain and maintain the selected position and/or velocity.

The velocity and position of the aircraft can be controlled by a Ground Control Station (GCS) operator by selecting the three-dimensional velocity or position commands relative to the reference vehicle by use of graphical displays on the command console. These displays can show the position and velocity of the aircraft in relation to the reference vehicle in a variety of coordinate systems, including Cartesian and polar coordinate systems. The operator can use an input device to select and drag the command to the desired value, point and click on the command, or type in the desired command on a keyboard. In addition, relative velocity or position can also be commanded from control sticks used by an operator, or commands may be autonomous, such as automatic launch or automatic approach and landing, wave off/abort landing, station keeping, or other preprogrammed commands and maneuvers.

BRIEF DESCRIPTION OF THE DRAWINGS

For a more complete understanding of the present invention, including its features and advantages, reference is now made to the detailed description of the invention taken in conjunction with the accompanying drawings in which like numerals identify like parts, and in which:

FIG. 1 is a perspective view of a ship and an aircraft that is being commanded by a flight-control system according to the present invention;

FIG. 2 is a perspective view of a landing pad located on the ship of FIG. 1;

FIG. 3 is a perspective view of a ground control station of the present invention;

FIG. **4** is a perspective view of a flight control box of the present invention;

FIG. **5** is schematic view of the components of a flight control system of the present invention;

FIG. **6** is a view of a first graphical display on the ground control station of FIG. **3**;

FIG. **7** is a view of a second graphical display on the ground control station of FIG. **3**; and

FIG. **8** is a schematic flowchart showing the steps of a method of the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The present invention provides a system for controlling a controlled vehicle in relation to a reference vehicle using relative velocities, which are determined by comparing the position and movement of the controlled vehicle with the position and movement of a known point.

For purposes of illustrating the system of the invention, the system will be described in reference to its use as a control system for an aircraft operating in conjunction with a ship at sea. The known point on the ship may be a touchdown point (TDP) for landing the aircraft. The relative velocity is zero if the aircraft is moving at the same velocity, i.e., same speed and direction, as the TDP. This invention allows precise aircraft velocity control relative to the TDP regardless of the speed of the TDP or the velocity and direction of the relative wind. A unique characteristic of this system is that the control of the aircraft velocity is independent of the aircraft heading, as the system allows an operator to be able to control the aircraft relative to a moving vehicle in a manner similar to the way that groundspeed is controlled relative to a point on the ground. As used herein, "velocity" will be understood as a vector, incorporating both a direction and a magnitude, though these may be discussed independently.

Though the system of the invention is described in use with an aircraft/ship combination, the system may be used for any combination and number of land, air, or sea vehicles or other moving objects where it is useful to control the position and velocity of a vehicle relative to a movable point or vehicle. Some examples of applications include use by a ground vehicle to control aircraft, by aircraft to control ground vehicles, by aircraft to control other aircraft, and by ground vehicles to control other ground vehicles.

Referring now to FIGS. **1** and **2**, an aircraft **11** is depicted as flying near a ship **13**. While shown in FIG. **1** as an unmanned tiltrotor-type aircraft, aircraft **11** may be of any type, and may be a fixed wing aircraft or other varieties of rotorcraft, and may be manned and controlled by a pilot. FIG. **2** shows a landing pad **15**, which is located on deck **17** of ship **13** and used for launching and/or recovering aircraft **11**. Though landing pad **15** is considered the TDP, the movement of landing pad is not independent of the movement of ship **13**. Therefore, ship **13** is considered a "reference vehicle" for determining the position and velocity of aircraft **11** relative to ship **13**, and the movement of the TDP and ship **13** may be used interchangeably.

In order to control aircraft **11** during flight or launch/recovery, a remote piloting system is used in conjunction with a semi-autonomous controller carried on aircraft **11**. Referring to FIGS. **3** and **4**, the operator interface for the system may be of several types, including a ground control station (GCS) **19** having graphical and numerical displays **21**, keyboards **23**, mouse **25** or similar input device, and audio/video components, as shown in FIG. **3**. Another example of the interface is a flight control box (FCB) **27**, as shown in FIG. **4**,

having a set of joysticks **29** or similar tactile input devices and graphical displays **31**. Aircraft **11** may be operated by one or more operators, with each operator using one of the operator interface devices. To illustrate the operation of the system of the invention, the system is described herein as comprising GCS **19** and FCB **27** for controlling aircraft **11**.

The basic mode of the system allows both the operators of GCS **19** and FCB **27** to command the velocity of aircraft **11** relative to ship **13**. Either of the operators can command the relative velocity from hover to the maximum airplane value, and GCS **19** can switch control back and forth from GCS **19** to FCB **27** as desired.

The major components of the system are shown in FIG. **5**. Components carried on aircraft **11** are denoted by bracket **33**, and components carried on ship, or reference vehicle, **13** are denoted by bracket **35**.

On aircraft **11**, a Global Positioning System (GPS) receiver module **37** receives transmitted signals **39**, **41** from orbiting GPS satellites, allowing GPS module **37** to determine the position of aircraft **11** in relation to the earth. Also, inertial movement sensors **43**, which may be accelerometers, measure the movement of aircraft **11** in three orthogonal axes, and a data receiver **45** receives data transmitted to aircraft **11** from components **35** on ship **13** and from GCS **19** and/or FCB **27**.

On ship **13**, a GPS receiver module **47** also receives GPS satellite signals (not shown) and determines the position of ship **13** relative to the earth, and inertial movement sensors **49** measure the movement of ship **13**. These data sources are combined to generate position and velocity data for ship **13**, and the data is then sent in a transmission signal **51** to data receiver **45** of aircraft **11** using transmitter **53**.

While not required to be located on the reference vehicle, GCS **19** and FCB **27** are typically located on ship **13**. GCS **19** and/or FCB **27** send a data transmission **55** to aircraft **11** for providing flight-control commands to aircraft **11**. As discussed below, transmission **55** communicates the selected position and/or velocity of aircraft relative to ship **13** that the operator desires for aircraft **11** to attain and maintain until a new command is given. In some embodiments, transmissions **51** and **55** may be sent using the same transmitter, for example, transmitter **53**. In addition, in those embodiments in which aircraft **11** is a manned aircraft, the pilot may transmit or otherwise input this transmitted data.

Data receiver **45** of aircraft **11** receives transmissions **51** and **55**, and the transmitted data is routed to a digital control system **57** carried on aircraft **11**. Additionally, the sensed data from GPS module **37** and sensors **43** are routed to control system **57**, and control system **57** calculates the position and velocity of aircraft **11** in relation to the earth, as well as the position and velocity of aircraft **11** relative to the reference vehicle, which is ship **13**. This calculated relative position and relative velocity is compared with the selected position and/or selected velocity communicated in transmission **55**, and an amount of error is determined. Control system **57** then commands various flight-control devices on aircraft **11**, such as throttle **59** and rudder **61**, to maneuver aircraft so as to minimize, and preferably eliminate, the error between the calculated and selected values. Other flight control devices commanded by control system **57** may include, as shown, ailerons **63**, flaps **65**, engine nacelles **67**, or other flight control devices **69**, including cyclic controls for rotors and blade angle actuators for propellers.

A key advantage of the present invention is that aircraft **11** is controlled relative to the reference vehicle and can be commanded to move in the direction that the controls of GCS **19** or FCB **27** are moved. The response is independent of the azimuth orientation of aircraft **11**. For example, if the opera-

tor wants the aircraft to move in the +X direction relative to the reference vehicle, then he will enter the desired system mode and move the X controller, such as one of joysticks **29** on FCB **27** (FIG. **4**) or a graphical icon on a display of GCS **19** (FIG. **3**), in the +X direction, and the commanded variable (position or velocity) relative to ship **13** will be changed in the X direction. This also applies to Y and Z directions.

FIGS. **6** and **7** illustrate two coordinate systems that can be used when controlling aircraft **11**. FIG. **6** shows a polar-coordinate, plan-view graphical display **71** that may be used by GCS **19** to send relative velocity commands to aircraft **11**. Display **71** includes a reference vehicle icon **73**, which represents ship **13**, in the center of concentric circles **74**. The heading of ship **13** relative to due north is indicated by the rotation of icon **73** in relation to a 360-degree compass **75** depicted on concentric circles **74**. A Cartesian coordinate system relative to ship **13** is depicted as axes **77** and **79**, wherein axis **77** is aligned with the current heading of ship **13** and icon **73**, and axis **79** is perpendicular to axis **77**. A line **81** points to the actual current location of aircraft **11** relative to ship **13**. As shown in the example of FIG. **6**, line **81** indicates that aircraft **11** is actually located a distance behind and slightly to the right of ship **13**.

A vector **83** indicates the aircraft velocity (both magnitude and direction) relative to the velocity of ship **13**. A small circle **85** indicates the desired terminus of the velocity commanded by GCS **19**. Circle **85** will be centered at the outer end of vector **83** when the actual velocity of aircraft **11** relative to ship **13** is equal to the desired velocity of aircraft **11** relative to ship **13**. Concentric circles **74** of display **71** indicate selected values of the magnitude of relative velocity. This magnitude increases as the velocity vector extends farther from the center of display **71**. Because display **71** represents a polar-coordinate command system, the magnitude of the relative velocity will not be negative. This configuration allows the heading of ship **13**, the commanded relative velocity of aircraft **11**, and the actual relative velocity of aircraft **11** to be quickly and easily ascertained by simply viewing display **71**. Should a GCS operator want to change the velocity of aircraft **11** relative to ship **13**, he simply clicks on circle **85** and drags circle **85** to the location on display **71** that represents the new relative velocity. This commanded, or selected, relative velocity is then transmitted to aircraft **11**, which is commanded by control system **57** (FIG. **5**) to make the necessary flight control adjustments to attain and maintain the commanded relative velocity. By commanding aircraft **11** to attain a relative velocity of zero, aircraft **11** will hold its position relative to ship **13**.

It should be appreciated that the system for manipulating icons on display **71** may include semi-automated actions, or shortcuts, that are programmed into the system. For example, the system may have a shortcut that allows the operator to command aircraft **11** to have zero relative velocity by right-clicking with a mouse or other input device at selected locations within display **71**.

The advantages provided by command display **71** when controlling the relative velocity of aircraft **11** are that the operator can command the relative velocity vector with one simple action, and he can also see the velocity of aircraft **11** relative to this velocity command. With one small display, the operator can have situational awareness and command control, plus observe all of the following information: (1) the ship heading direction relative to the compass; (2) the direction of the aircraft position relative to the ship; (3) the direction of the aircraft velocity relative to the ship; (4) the magnitude of the aircraft velocity relative to the ship; (5) the magnitude of the

commanded velocity relative to the ship; and (6) the direction of the commanded velocity relative to the ship.

Though described above as used for controlling velocity, polar-coordinate display **71** may alternatively be configured to allow positioning of aircraft **11** relative to ship **13**, though this is preferably used only when aircraft **11** is located far from ship **13**. During such use, an icon (not shown) representing the position of aircraft **11** can be dragged to the desired location on display **71** relative to ship **13**, and aircraft **11** may have a zero relative velocity, i.e., station-keeping, or a selected relative velocity to resume from the commanded position. When used for position commands, concentric circles **74** on display **71** act as range, or radius, indicators. Shown in FIG. **6** is a triangular icon **87** that indicates a preprogrammed station point that is set up to be relative to ship **13**, shown here as being a distance directly behind ship **13**.

A Cartesian-coordinate, plan-view display **89** on GCS **19** is shown in FIG. **7**. The Cartesian coordinates are preferably used only when aircraft **11** is near to ship **13**. An icon **91** represents aircraft **11** on approach to a representation of TDP **93** on deck **95** of ship **13**. The coordinates are in the X, Y system, with a range guide **97** indicating distance from TDP **93**. Display **89** may be configured to allow the operator of GCS **19** to manipulate icon **91** for controlling the movement of aircraft **11** by dragging icon **91** relative to ship **13**, as represented by deck **95**. Alternatively, display **89** may be configured as an information-only display, which does not allow direct control of aircraft **11** by manipulating icon **91**.

The operator of FCB **27** can also command aircraft **11** in either the polar or Cartesian coordinates after control has been transferred from GCS **19** to the FCB **27**. When control is switched to the FCB, the joysticks **29** will be in the centered position, which will command the relative velocity to remain at its present value. This means that aircraft **11** will continue with the same velocity relative to ship **13**, and in the same direction until the FCB operator commands a relative velocity change. The FCB operator can command an increase or decrease in velocity by moving a longitudinal joystick forward or rearward, respectively, and the velocity command will change proportional to stick displacement. When in polar mode, the direction of the velocity can be changed by moving a lateral joystick on FCB **27**, such that left and right lateral stick motion will command the velocity vector to rotate in the counterclockwise and clockwise directions respectively, at a rate proportional to stick displacement.

The operator of FCB **27** also has the capability to fly the aircraft by commanding velocity in the ship coordinate system, which is an X, Y system. This mode is required for manually positioning the aircraft over the deck, or TDP, of the moving ship, or performing manual landings. The forward and rearward movement of the longitudinal joystick will command velocity in the X direction (fore and aft on the ship deck), and the right or left movement of the lateral joystick will command a velocity in the Y direction (port and starboard on the ship deck). The forward motion on the controller will preferably command a velocity toward the rear of the deck, and a right motion will preferably command a velocity toward the port side of the deck. When the joysticks are centered, aircraft **11** will be commanded to hold its present position relative to the TDP. These conventions were chosen because the operator of FCB **27** will be facing toward the rear of the deck as aircraft **11** approaches, and this convention will move aircraft **11** the same direction as the stick motions. Velocities are commanded in the X, Y coordinate system instead of in the aircraft axes in order to make the commands independent of the heading of aircraft **11**.

One application that is particularly well suited for the control system of the invention is maneuvering an aircraft into an acquisition window for another control system. For example, the aircraft may be maneuvered into a window for acquisition by an auto-recovery or landing system.

FIG. 8 is a flowchart illustrating the method of relative-velocity control of the system of the invention. The method begins with step 99, in which the sensor system carried on an aircraft determines the position and velocity of the aircraft relative to the earth. In step 101, the aircraft receives a data transmission communicating the position and velocity of a reference vehicle, which is used in step 103 with the sensed data from step 99 to calculate the velocity and/or position of the aircraft relative to the reference vehicle. Flight-control devices are commanded in step 105 so as to fly the aircraft to a desired relative velocity and/or position. An optional step 107 is also shown in which transmitted data communicating the desired relative velocity and/or position is received by the aircraft.

An additional advantage of the control system of the invention is that it allows for control of aircraft 11 using various autonomous and semi-autonomous modes, including:

1. Auto-recovery: In this mode, the operator maneuvers aircraft 11 into an acquisition window, then commands the auto-recovery system to land aircraft 11 on the TDP. An X,Y,Z coordinate system is defined with the positive X axis out the stem of the ship, with the option of rotation to a specified approach angle. Y is positive out the starboard side, and Z is positive in the up direction. Once acquired, the sensors on ship 13 track aircraft 11, and three-dimensional position data are sent to GCS 19, which in turn transmits these positions to aircraft 11.

2. Auto-approach: The approach phase commands the aircraft to follow a preset approach profile from its present location to a point over the TDP. The approach profile specifies a velocity in the X direction and Z position (height) as functions of distance from the TDP. The approach profile requires the aircraft Y position to go to zero and hold at zero throughout the approach, meaning aircraft 11 is aligned with the desired approach angle to ship 13. When the aircraft has arrived near the TDP, a position-hold function will be engaged to hold aircraft 11 in a hover over the TDP.

3. Deck Following: After the position hold is engaged, aircraft 11 can be commanded to start following the deck surge heave and sway motions, keeping aircraft 11 in a selected position relative to the TDP.

4. Descend to the Deck: Descend to the deck is the final phase of auto-recovery, in which aircraft 11 is commanded to descend at a specified rate relative to the TDP.

5. Waveoff/Abort: If the operator of the GCS 19 or FCB 27 chooses, aircraft 11 can be commanded to waveoff, and it will execute a predetermined maneuver to move away from ship 13. Aircraft 11 moves in the positive X direction (to the rear of ship 13) and enters a gentle vertical climb for a predetermined period of time after which the relative velocity vector is commanded to zero and the aircraft altitude is held at its then present value.

An abort is automatically entered if failure management logic of the control system determines that the auto-recovery cannot be completed. The reasons for abort may include excessive position or velocity errors, failures or loss of parts of the control system, and loss of data uplink. The control of aircraft 11 during an abort is preferably the same as for a waveoff, the only difference being that an abort is initiated automatically and a waveoff is initiated by the GCS or FCB operator.

6. Fly-To-Station: The Fly-to-Station mode allows the GCS operator to specify a point at a distance and direction from ship 13 to which aircraft 11 will fly automatically. Aircraft 11 accelerates to a prescheduled velocity profile, flies to the designated location, decelerates and stops at that location. It then holds relative position there until commanded to do otherwise. This mode is a convenient way of commanding the aircraft to fly to the acquisition window, from which the aircraft is acquired, and the auto-recovery is initiated. This type of mode may also be used automatically to send aircraft 11 to a predetermined location and fight path if data communication is lost.

The present invention provides significant advantages over the prior art, including: (1) the autonomous control of aircraft that commands the aircraft to attain and maintain the selected position and/or velocity of the aircraft relative to the reference vehicle by comparing values from onboard sensors with data transmitted to the aircraft indicating the velocity and position of the reference vehicle; (2) the easy control of aircraft relative to a moving vehicle without the operator having to consider the position or velocity of the aircraft in relation to the earth; (3) the control of the velocity of the aircraft relative to the reference vehicle by manipulating a representation of the terminus of the relative velocity vector on a graphical display to a desired angle and magnitude relative to the velocity of the reference vehicle; (4) the control of the position and/or velocity of the aircraft relative to the reference vehicle by manipulating tactile input devices, such as joysticks.

While this invention has been described with reference to illustrative embodiments, this description is not intended to be construed in a limiting sense. Various modifications and combinations of the illustrative embodiments, as well as other embodiments of the invention, will be apparent to persons skilled in the art upon reference to the description.

The invention claimed is:

1. A system for controlling flight of an aircraft comprising:
a sensor system disposed on the aircraft for sensing a position of the aircraft and an inertial movement of the aircraft, the sensor system being adapted to communicate sensed data representing the position and the inertial movement of the aircraft;
a receiver disposed on the aircraft and adapted to receive transmitted reference data communicating a position and movement of a reference vehicle;
commanded data representing a selected velocity of the aircraft relative to the reference vehicle; and
a control system disposed on the aircraft for calculating a calculated velocity of the aircraft relative to the reference vehicle using the sensed data and the reference data and for controlling flight-control devices on the aircraft, such that the aircraft attains and maintains a selected velocity relative to the reference vehicle corresponding to the commanded data;
wherein the commanded data is preprogrammed into the control system prior to flight of the aircraft.

2. A system for controlling flight of an aircraft comprising:
a sensor system disposed on the aircraft for sensing a position of the aircraft and an inertial movement of the aircraft, the sensor system being adapted to communicate sensed data representing the position and the inertial movement of the aircraft;
a receiver disposed on the aircraft and adapted to receive transmitted reference data communicating a position and movement of a reference vehicle;
commanded data representing a selected velocity of the aircraft relative to the reference vehicle; and
a control system disposed on the aircraft for calculating a calculated velocity of the aircraft relative to the reference

vehicle using the sensed data and the reference data and for controlling flight-control devices on the aircraft, such that the aircraft attains and maintains a selected velocity relative to the reference vehicle corresponding to the commanded data;

 wherein the receiver is further adapted to receive a transmission communicating the commanded data; and

 wherein the commanded data is generated using a control station remote to the aircraft by manipulating a graphical user interface.

3. The system according to claim **2**, wherein the commanded data is transmitted from the reference vehicle.

4. A system for controlling flight of an aircraft comprising:

 a sensor system disposed on the aircraft for sensing a position of the aircraft and an inertial movement of the aircraft, the sensor system being adapted to communicate sensed data representing the position and the inertial movement of the aircraft;

 a receiver disposed on the aircraft and adapted to receive transmitted reference data communicating a position and movement of a reference vehicle;

 commanded data representing a selected velocity of the aircraft relative to the reference vehicle; and

a control system disposed on the aircraft for calculating a calculated velocity of the aircraft relative to the reference vehicle using the sensed data and the reference data and for controlling flight-control devices on the aircraft, such that the aircraft attains and maintains a selected velocity relative to the reference vehicle corresponding to the commanded data;

 wherein the receiver is further adapted to receive a transmission communicating the commanded data; and

 wherein the commanded data is generated using a control station remote to the aircraft by manipulating a tactile user interface.

5. The system according to claim **4**, wherein the transmitted data communicating the position and movement of the reference vehicle are transmitted from the reference vehicle.

6. The system according to claim **4**, wherein the sensor system determines the position of the aircraft using a Global Positioning System receiver module.

7. A system for controlling the flight of an aircraft comprising:

 sensors carried on the aircraft, the sensors being adapted to determine the position of the aircraft relative to the earth and the inertial movement of the aircraft, the sensors also being adapted to output data communicating the position and movement of the aircraft;

 a receiver carried on the aircraft and adapted to receive transmitted data communicating the position of a reference vehicle relative to the earth and movement of the reference vehicle relative to the earth; and

 a control system carried on the aircraft and connected to the sensors and the receiver, the control system calculating the position of the aircraft relative to the reference vehicle and movement of the aircraft relative to the reference vehicle using the data from the sensors and the data received by the receiver, the control system being adapted to command flight-control devices on the aircraft for causing the aircraft to maneuver in a manner that attains and maintains a selected position relative to the reference vehicle or a selected velocity relative to the reference vehicle;

 wherein the selected position and velocity of the aircraft relative to the reference vehicle is selected and input into the control system prior to flight of the aircraft.

8. The system according to claim **7**, wherein the receiver is adapted to receive data communicating the selected position and velocity of the aircraft relative to the reference vehicle.

9. The system according to claim **8**, wherein the data communicating the selected position and velocity of the aircraft relative to the reference vehicle is transmitted from the reference vehicle.

10. The system according to claim **7**, wherein the data communicating the position and movement of the reference vehicle is transmitted from the reference vehicle.

11. The system according to claim **7**, wherein the sensors determine the position of the aircraft using a Global Positioning System receiver module.

12. A multi-vehicle system comprising:

 a reference vehicle;

 at least one aircraft;

 a reference sensor system carried on the reference vehicle and adapted to determine the position relative to the earth and the movement relative to the earth of the reference vehicle;

 an aircraft sensor system carried on each aircraft and adapted to determine the position relative to the earth and the inertial movement of each corresponding aircraft;

 a receiver carried on each aircraft for receiving transmitted data communicating the position and movement of the reference vehicle; and

a control system carried on each aircraft adapted to calculate the velocity of each corresponding aircraft relative to the reference vehicle and adapted to command flight-control devices for causing each corresponding aircraft to fly at a selected velocity relative to the reference vehicle;

 wherein the reference vehicle is a ship.

13. A multi-vehicle system comprising:

 a reference vehicle;

 at least one aircraft;

 a reference sensor system carried on the reference vehicle and adapted to determine the position relative to the earth and the movement relative to the earth of the reference vehicle;

 an aircraft sensor system carried on each aircraft and adapted to determine the position relative to the earth and the inertial movement of each corresponding aircraft;

 a receiver carried on each aircraft for receiving transmitted data communicating the position and movement of the reference vehicle; and

a control system carried on each aircraft adapted to calculate the velocity of each corresponding aircraft relative to the reference vehicle and adapted to command flight-control devices for causing each corresponding aircraft to fly at a selected velocity relative to the reference vehicle;

 wherein the reference vehicle is a land-based vehicle.

14. A flight control system for controlling the velocity of an aircraft relative to a reference vehicle comprising:

 a control station carried by the reference vehicle; and

 a hand-held controller; wherein either the control station or the hand-held controller may be used to control the velocity of the aircraft relative to the reference vehicle.

15. The flight control system according to claim **14**, wherein the hand-held controller includes tactile input devices.

16. A graphical display for controlling the velocity of an aircraft relative to a moving vehicle, comprising:

 a moving-vehicle icon representing the moving vehicle;

 a velocity-vector icon representing the actual velocity of the aircraft relative to the moving vehicle;

 a commanded-relative-velocity icon representing a selected velocity of the aircraft relative to the moving vehicle;

wherein the velocity of the aircraft relative to the moving vehicle may be selectively controlled by moving the commanded-relative-velocity icon within the graphical display.

17. The graphical display according to claim **16**, wherein the graphical display is programmed to generate signals for controlling the aircraft in response to the movements of the commanded-relative-velocity icon.

18. The graphical display according to claim **16**, further comprising:

a relative-velocity-magnitude icon representing the velocity of the aircraft relative to the moving vehicle.

19. The graphical display according to claim **18**, wherein the relative-velocity-magnitude icon is a plurality of circles concentric about the moving-vehicle icon.

20. The graphical display according to claim **16**, wherein the velocity-vector icon changes in response to the movements of the commanded-relative-velocity icon, so as to represent the aircraft attaining and maintaining the selected velocity of the aircraft relative to the moving vehicle.

21. The graphical display according to claim **16**, further comprising:

a polar coordinate system for indicating the heading of the moving vehicle.

22. The graphical display according to claim **16**, further comprising:

a Cartesian coordinate system linked to the moving-vehicle icon to aid in selecting the movements of the commanded-relative-velocity icon.

23. The graphical display according to claim **16**, further comprising:

an aircraft-location icon representing the current physical location of the aircraft relative to the moving vehicle.

24. The graphical display according to claim **16**, further comprising:

a station-keeping icon representing a preprogrammed position or velocity of the aircraft relative to the moving vehicle.

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